BELL TELEPHONE QUARTERLY

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OCTOBER, 1933

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AMERICAN TELEPHONE & TELEGRAPH CO.
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A Medium of Suggestion and a Record of Progress

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The Engineer and a Century of Progress

Editor's Note:

The following address by Mr. H. P. Charlesworth, Assistant Chief Engineer of the American Telephone and Telegraph Company, was delivered by him on June 26, 1933, as President of the American Institute of Electrical Engineers, at its summer convention, which was held at Chicago, Illinois.

WE ARE gathered here at Chicago this week not only to participate in our usual summer convention, but also in a coming together of the greatest conclave of engineers of our own and other professions that ever has assembled or that may assemble again for many years to come. The occasion of this assembly is in a sense a celebration of a century of progress so admirably portrayed by the wonderful monument to human advancement that has been spread out along the shores of Lake Michigan, through the courageous efforts of the people of Chicago in honor of the centennial of the incorporation of Chicago as a village.

It is an interesting coincidence to those of us who are electrical engineers that electrical science is approximately the same age of the City of Chicago. It was just 100 years ago that Faraday in England, Henry in the United States, and other great scientists building upon the work of Ohm, Ampere, Oersted, and others, were completing the foundation of fundamental principles upon which have been erected the vast fabrics of applied arts and industries which are the concern of the electrical engineer today.

The wonderful exhibition here in Chicago, aptly termed "A Century of Progress," presents the progress of man during the past century in particular. It is most fitting, therefore, that

we should find here gathered together engineers and scientists from all parts of the world, especially when we recall the great contributions to this progress made by them individually and collectively. What is more important, however, is that we are, I believe, consciously or unconsciously, carefully weighing the progress which has already been made to the end that we may gain courage to carry us through our present difficulties and inspiration to plan for still greater achievements in the future, not alone in the material things of life, but also in the broader aspects of human advancement.

During the past 50 centuries or so of historical time and throughout the unnumbered centuries that preceded them, the story of mankind has been primarily a struggle for existence. We need go back only a comparatively few years to observe the scarcity of machines and mechanical aids that were available. Indeed, using his hands alone, the average man had to work from early morning often far into the night merely to provide food, clothing, and shelter. Today, this average individual has material comforts that not so long ago would have been the envy of the favored few.

Surrounded as we are with safe and comfortable modes of living, it is difficult to appreciate adequately the status of mankind during that earlier period. Yet, it is essential that we should vividly picture his trying existence if we are fully to appreciate the degree of our progress and the relative unimportance of some of the hardships resulting from our present difficulties. To draw our comparison properly we must study carefully the life of the masses of people in the earlier centuries, and thus secure some picture of the hardships of living, often in isolation with no ready means of transportation or communication, with heat and shelter depending upon the crudest facilities, sustenance often on single crops subject to the vicissitudes of the weather; with life as a whole frequently controlled by the whims of a despot or warring factions. An existence, therefore, for the average man much like that char-

acter in Grecian mythology who, in the Lower Regions, was condemned eternally to roll the stone of forlorn hope up the steeps of despair.

How different the picture as we contrast these earlier conditions with our present state of civilization, and contemplate what has been accomplished in improving our existence and removing drudgery from our daily tasks. We cannot fail to recognize, therefore, that, during the past century in particular, science more than any other single factor has influenced human affairs and added to the opportunities for a broader and happier life.

In spite of this evidence on every hand of real benefit which mankind has secured through the progress of science and engineering, we occasionally find arising in some quarters, and particularly under the difficult times through which we have passed, a fear of science and its effect upon us. We hear that there should perhaps be a holiday in the field of research and in the new applications of science. To any intelligent and thoughtful person it is evident how foolish and vain both these points of view are and I think we may view with satisfaction the fact that we have been in no way influenced by these false premises, but rather that we have adhered steadfastly to the sound principles upon which our progress has been based.

We know full well that we cannot set up arbitrary or effective bars against man's curiosity of the unknown, or the researches which follow from that curiosity, nor can we long delay the introduction of things which man believes to be valuable additions to his social life. Furthermore, from our own experience, we have seen ample evidence, and there are constantly spread out before us many examples of the fact that such advances should not be retarded but on the contrary, are the very instrumentalities upon which our future progress must be based.

It is true, of course, that we have been passing through difficult times and have experienced during the past 20 years two

of our greatest catastrophes, namely the World War and the present world-wide industrial depression. We find ourselves today in a world which has experienced undue privation and want, full of anxiety and uncertainty, and here and there in actual discord. Perhaps it is not surprising, therefore, that some have questioned: "Has this really been a century of progress?" However, I am sure that there is ample proof that the present crisis from which we are emerging cannot wipe out the experience of a century of lessons or the real measure of our progress which is to be derived therefrom.

Progress is defined as "a moving or going forward, an advance toward better or ideal knowledge or condition or that conceived of as better." In other words progress is an advance toward a goal and in order to determine whether or not progress is being made, it is necessary first to define our goal. I believe that there is general agreement that the goal toward which mankind is striving is an increase in human happiness in its broadest sense. Our goal remains poorly defined, however, until we express in some more concrete way the conditions that are expected to lead to the greatest happiness of all mankind. One would be bold, indeed, to attempt a detailed definition of this matter which has to do with so many factors concerning the whole relationship of man to man and of man to his environment. May I venture, however, the suggestion that this involves primarily three things: first, the easy provision of the necessities of life, including among necessities the things commonly used by the social group; second, a sense of security obtained by minimizing the number and extent of those catastrophes which destroy or disrupt human life; and third, the capacity and opportunity through leisure for appreciation of the world and of the people and things in it, with the development of character and culture.

Now I think, particularly in view of the history of recent years, it must be admitted that the progress made in the last century, as thus broadly defined, has by no means kept pace

with technological advances. The applications of science have opened opportunities for increased comforts, for decreasing the number of hours of labor required for producing the necessities of life, and for providing the surplus productivity which should lead to security and give men the leisure in which to develop and exercise the capacity of appreciating the world in which they live. As I see it, the difficulty is that these rapid developments in the material things of life naturally require the continuous adjustment of society, and up to the present time social reorganization has not kept pace with our material advances.

This is not a condition of recent years alone. It appears to have been a chronic condition of society. It involves many factors, among which is a lack of appreciation of what science is accomplishing for mankind. This can be illustrated in many ways, as for example, by the opposition with which many important advances have been greeted, particularly in earlier days. Developments that are evidently of great benefit to mankind, in one way or another, repeatedly have been opposed even by those who should be in the best position to realize the ultimate advantages of the new device. We smile when we read a 17th century protest against the "large coaches" which were about to be placed in service between London and York and which would carry as many as 18 passengers and would make the trip of 175 miles in 4 or 5 days. We note "the vast amount of employment those eighteen persons would give to grooms, farriers, innkeepers, hostlers, saddlers, etc., if each were to ride his own horse instead of adopting the revolutionary practice of clubbing for a common conveyance." Again, we recall with interest, that when attempts were made to introduce the saw mill in England they were opposed violently; yet we know that soon it became recognized that through its use human effort could be conserved, new products looking toward human comfort could be provided at reasonable cost, and through the diversity of the mill the opportunity for employment actually be increased. And so might be cited

similar examples in every phase of our industrial progress. Fortunately, with a growing understanding of what science is accomplishing there has been less opposition and material progress has been possible but other serious problems have presented themselves.

While, therefore, any well considered study of our advancement particularly in the past century, cannot but lead to the conclusion that science and invention have been the life blood of our progress, it must be recognized that during this period science has injected into human life a multitude of factors with which our forefathers did not have to deal, but with which we and our successors must reckon. The sooner we approach a better understanding of these factors and how to deal with them in an intelligent and forward-looking manner, the sooner will we make for real progress in the broader problems that confront us. In other words, we must recognize and understand these new factors so as to weave them properly into our social structure. The application of science is placing in the hands of individuals, and of nations, vast powers for good or evil, far greater than those of any earlier century. Hence, the pace of humanity, in any direction in which it is advancing, constantly quickens. With this has come an increase in the complexity of social relationship brought about through a closer and closer interdependence of the different parts of the world.

All this, it seems to me, must have an important bearing on the work of the engineer. In the earlier days, we find the scientist and the engineer working in a large measure in isolation, and working, in turn, on the many phases of a problem often not too well defined. As time progressed, and to an increasing extent during the past century, we have found large groups coming into existence for the study and furtherance of research and engineering. Today the modern research or engineering problem is being approached by a group attack; that is, the problem is being defined as far as practicable and specialists

in their respective fields are being assigned to its various parts. And so we find the engineer depending to a greater and greater extent upon his fellows, not only in his own profession, but also in the other branches of the arts and sciences. Not only is this true in industry itself, but in order that their work may be carried on effectively and to the end that they may be qualified and keep in step with the rapid progress experienced particularly during the last half of the past century, engineers have had a greater and greater tendency to come together into great organizations such as our own society. In more recent years we find a growing recognition that not only must we be banded together in our own profession, but there must be a growing tie between engineers generally. Thus came into being the American Engineering Council and similar organizations which already have done so much for the profession and for the nation.

As I view the situation, however, these activities alone will not be sufficient. We must be prepared to take an even greater part in public problems and to assist in the affairs of society generally through daily contacts as citizens of our communities and of the nation. In some respects the engineer seems to me to be in a position to make a special contribution. He should have a clear perception of the nature of the revolutionary technical changes through which the world is going, of their effect on human life and on the social problem. Furthermore, if he has, as he should have from his training, developed the scientific habit of thought, that is, approaching the problem from the standpoint of determining the facts and reasoning from those facts to the conclusions, he should be able to bring something of real value to bear upon the problems of social reorganization. He has come to realize through years in the hard school of experience that things cannot be taken for granted, that the best way of doing a thing today may be far from the best way of doing it tomorrow.

The social problem involves all the people and its solution

requires the continuous effort of men of all vocations who can contribute to it. As I see it, therefore, in embarking upon our work of the next century we should find the engineer not only working in closer association with his fellows in the field of science and engineering, but, if he is to prove of greatest usefulness, also developing a closer association with other groups of society. To the extent that we effectively recognize these new responsibilities and opportunities, we will, I am sure, make still greater contributions to the benefit of mankind. As we enter upon these broad responsibilities of our profession, we should proceed with characteristic purposefulness, always remembering, however, that in many cases our greatest help can be by contributions within the limit of our knowledge and experience, rather than attempting alone to direct in fields where considerations beyond the scope of engineering must weigh heavily in the final decisions.

Opportunities for constructive help present themselves on every hand, particularly in times like the present. Basically there is need from the very beginning for a better understanding of the effects and results of science and engineering on our daily existence. We who have made this our life work are, it seems to me, in the best position to foster a real understanding of what science is and what it reasonably can be expected to accomplish or not accomplish and the methods by which those results can be employed most effectively. This greater knowledge is necessary not only to scientists and engineers, but also to those who make up society generally. It seems to me, therefore, that this becomes one of our fundamental responsibilities.

To appreciate the importance of the broader understanding, we have but to look about us and consider what has been going on in many fields where a full recognition of the effects of science has not been taken into account. Despite the rapid progress that has been made and the marked effect which new developments, that can often be foreseen, may have on products

or procedures, we often have seen planning and financing carried on year after year without a recognition of the effects which these rapid changes have on industries or individual projects in question. In many industries based on science it has been found to be as important to know about their research or engineering organizations and of the attitude of the management toward these activities as it is to know about their financial status. Again, in the case of agriculture for example, we often have seen efforts being directed toward greater and greater production of a given product of the soil when overproduction as a whole already was in evidence. Too many great undertakings have been carried forward without reflecting adequate advance planning; and conversely, other projects that have had a full measure of such consideration devoted to them stand out as marked examples of the value and importance of such an approach.

Not only can the engineer be helpful in those matters in which his profession is directly concerned but also in the broad problems which today confront our nation and the world. Many of these do not involve engineering matters, but nevertheless do require the same careful planning and foresight which enter into our daily engineering undertakings. If, in our individual capacities as good citizens, we can apply some of this attitude of mind and instill in others the importance of this approach to some of these problems, I am confident we can make contributions of great value in these broader fields as we have in the fields of science and engineering. The need for some such approach to the problem is all too evident when we consider some of the spectacular proposals which, although based on such an utter disregard of fundamental facts, are submitted from time to time as cure-alls for the troubles of the world.

Gradually through a general understanding of science and the application of the principles of straight thinking to some of our broader problems, we should be able to make progress

in the field of social organization as man has in the material aspects of human advancement. That we should be able to make this broader progress, I believe there can be no doubt, for, in the recent words of President Roosevelt, "Certainly the human intelligence that has accomplished the industrial and cultural results displayed at your Exposition need not fall short of devising methods that will insure against another perilous approach to collapse such as that from which we are now emerging. . . . The advance of science and the evolution of humanity and charity made it known to us that whatever is the result of human agency is capable of correction by human intelligence. Who is there of so little faith as to believe that man is so limited that he will not find a remedy for the industrial ills that periodically make the world shiver with doubt and terror?"

As I have indicated already, there is opportunity for the engineer to make substantial contribution to the advance of this side of our social welfare. That he may prepare himself to take this broader responsibility, he must, as I see it, adjust himself to an even broader viewpoint, and acquire a more intimate knowledge of the economic forces and social problems of our daily life, than he has in the past. That he will be able to do so I have no doubt. As our engineering educators so wisely have appreciated, this trend also must be fully reflected in the training of the younger men who are to become the leaders in the future. If we thus can make progress toward a better equilibrium between our technical and social knowledge and reflect its effect upon the advancement of society generally, then I believe we may look with real hopefulness to a nearer approach to our goal of progress as previously interpreted.

The development of culture requires leisure from the struggle for existence, and such leisure gives us opportunity in turn for the development of things of the mind and of the spirit. At various times in history, periods of culture have been experienced. Often, however, this has come about through op-

portunity for leisure for the few by imposing drudgery on the many. Can we not look upon science, however, coupled with a proper utilization of the products of science, as the medium through which we now may secure a reasonable degree of leisure for the greatest number? With this, no doubt, comes the added advantage of tending not toward lack of initiative coupled with that leisure, but toward creation of leisure through initiative itself. May we not then feel that we have really built on a firm foundation for progress?

If we of the engineering profession, working in full cooperation with all other groups of society, can contribute in some measure to this further progress of mankind, we may justly take pride in the service we render and feel with satisfaction that again we have widened our sphere of social responsibility. Society, I believe, has come to expect of us a devotion to the truth wherever the facts may lead us and an aim toward unbiased judgment. We should safeguard this trust which is placed in us and continue our efforts along those channels of endeavor wherein we may be of greatest help, and in those fields where we are best qualified to advise, to the end that we always may be of greatest service to society as a whole. If we can so govern our efforts in the period ahead and broaden our knowledge and approach to a better molding of the social and material sides of life, we will have done our part in making the world a better and happier place for our fellowmen and will reap the satisfaction that comes to all of us from worthwhile endeavor.

H. P. CHARLESWORTH

The Vacuum Tube in Telephone Communication

MR. BROWN of New York, as he talks with Mr. Smith of Los Angeles, is no longer surprised that he can talk with ease over such a distance but would, no doubt, express astonishment if he were told that some 200 vacuum tubes were directly involved in his conversation. The circuit over which he talks would probably be made up of four wires in cable between New York and St. Louis and a carrier circuit on open wire from St. Louis to Los Angeles. Many of the 200 vacuum tubes are distributed at intervals along the line in telephone or carrier repeaters where they serve to amplify the speech currents after they have become attenuated by the line. Other vacuum tubes, at the beginning of the carrier part of the circuit, serve to step up the pitch or frequency of the voice currents several octaves. Still others at the end of the carrier link step the frequency of the currents down again to their natural pitch. This permits the line to carry at the same time other telephone conversations, each of which is kept distinguishable from the others by being transposed in frequency by vacuum tubes to its own particular pitch or frequency assignment on the line.

Besides the vacuum tubes thus directly involved in the transmission of the speech there are others which are essential parts of the signaling arrangements used by the operators at the two ends of the circuits to signal each other, and of the oscillators and transmission measuring devices by means of which such a complex thing as a transcontinental circuit is kept functioning properly.

The above example illustrates the important part which the vacuum tube has played in extending the range of the human voice. The use of the vacuum tube is not confined to very long circuits, however, for substantially all telephone circuits

more than 100 miles or so in length, and some much shorter even than this, employ vacuum tubes in telephone repeaters or other apparatus.

The growth in importance of the vacuum tube has brought about a far-reaching change in the telephone engineering art. The vacuum tube has made available an important new tool and has brought in many associated developments with which every telephone transmission engineer must be familiar. He must know a great deal about the theory entering into the design of telephone repeaters, carrier apparatus, etc. He must be conversant with such related things as electrical filter design, and the design and manufacture of toll cables to obtain uniform characteristics and low crosstalk. He must know how to lay out circuits so as most effectively to use vacuum tube apparatus having in mind the economies involved and the overall performance.

The trends in the design of the wire plant itself have been greatly influenced by the vacuum tube. In the early part of this century the only method known to extend telephone communication to longer and longer distances was to reduce the attenuation of the lines by using larger and larger wire conductors and later by loading them heavily with inductance coils. The possibilities in these directions were soon exhausted and some sort of means for amplifying the speech currents was urgently needed. For a while a limited use was made of "mechanical repeaters," whose amplifying units consisted essentially of a telephone receiver talking into a transmitter—in actual fact a "repeater." The advent of the vacuum tube opened up new possibilities, however, and now because of the use of frequent vacuum tube repeater stations along the lines, it is possible to construct the wire plant more cheaply by using smaller gauge wires, and, where the volume of traffic warrants it, by placing many wires in the same lead sheath of a toll cable. Moreover, it is the present custom to load the wires only lightly with loading coils or in the case of open-wire lines not to load

them at all. Enough has been said to show that much of the modern art of long distance telephony is built around and is dependent upon the vacuum tube.

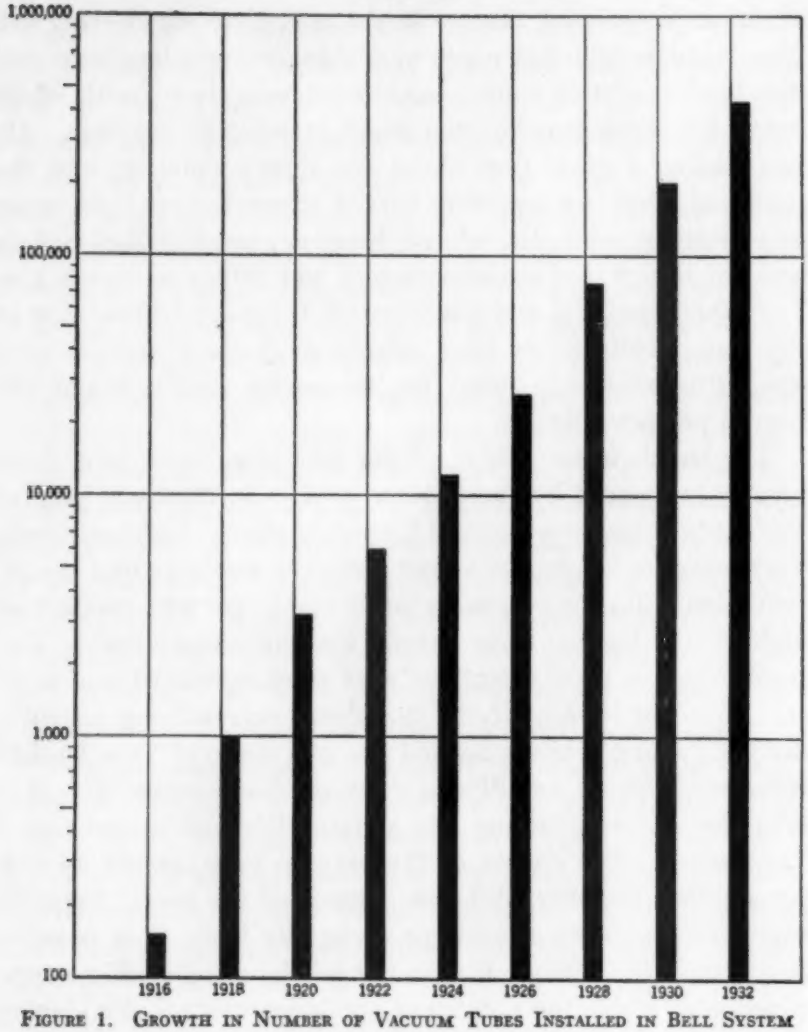

FIGURE 1. GROWTH IN NUMBER OF VACUUM TUBES INSTALLED IN BELL SYSTEM PLANT.

Vacuum tubes were first used in regular commercial service in the telephone plant about the beginning of 1914. Their number increased rapidly, more than doubling every two years,

until at the beginning of 1932 there were over 350,000 in service in the Bell System. This growth is illustrated graphically in Fig. 1. The tubes are divided among the various types of plant about as follows:

Telephone repeaters	65	per cent
Ringers	10	" "
Carrier telephone and telegraph systems	20	" "
Program repeaters, echo suppressors, transmission testing equipment, etc.	5	" "

These are the principal classifications based on the quantities of tubes in service. For completeness, however, mention could be made of a number of other types of apparatus which employ tubes although not in sufficient quantities to loom large in the totals. These include public address systems, the amplifiers used in the time-of-day service in the larger cities, the telephotograph apparatus and the radio stations forming the American terminals of the radio links with Europe, South America, Central America, Bermuda, Hawaii, the Philippines and ships at sea.

The vacuum tubes used in these various types of apparatus are of all sizes ranging from the miniature "peanut" tube with a power output rating of about one-hundredth of a watt to the large water-cooled tubes with power output ratings of many thousands of watts. About 90 per cent, however, of all of the vacuum tubes in the telephone plant are of the two types familiarly known to telephone engineers as L and V tubes. These two types account for nearly all of the tubes used in the telephone repeaters, carrier systems and ringers. Although many improvements have been made from time to time which have decreased their power consumption, and increased their uniformity and average life these general types have been continued from the earliest days of the commercial application of vacuum tubes to telephony. The 1933 models of these tubes are illustrated in the accompanying pictures.

Long after their introduction into telephony, vacuum tubes have in recent years been popularized by their widespread use

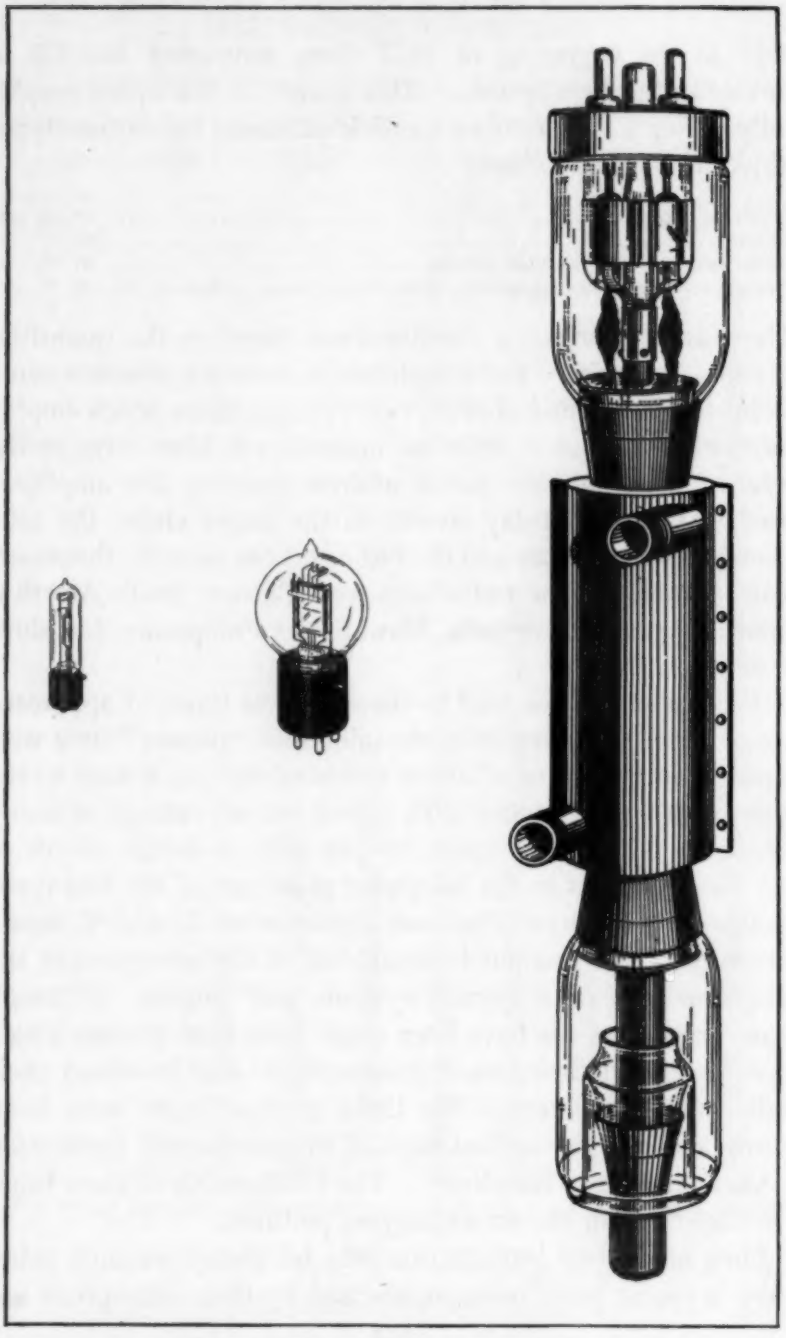

FIGURE 2. "PEANUT" TUBE, "L" TUBE AND 10 KILOWATT WATER-COOLED TUBE SHOWN TO SAME SCALE.

in radio broadcast receiving sets. Nearly everyone is now familiar at least with the appearance of a vacuum tube. Very many have some degree of technical appreciation of the manner in which a vacuum tube may be used as a rectifier to transform alternating to direct currents, as an oscillator to transform direct to alternating currents, as an amplifier to amplify either direct or alternating current, or as a modulator, demodulator or detector to modify the frequency of an electrical current. It is, therefore, not important to discuss in a technical manner the way in which a vacuum tube works.

We are interested, however, in noting the special problems which distinguish the application of vacuum tubes to telephony from other applications such as radio. In serving these different applications, the vacuum tube finds telephony the harder taskmaster. To give satisfactory service, it must meet stringent requirements in regard to long life, uniformity, stability and freedom from distortion of the voice currents. In a radio set, the vacuum tubes may depart considerably from their ideal performance before the listener becomes aware that something is wrong, for the human ear is too coarse an instrument with which to detect even fairly large changes in volume or quality. In a telephone circuit, however, so many tubes may be in tandem that their individual performance must be almost perfect if the cumulative effects of the distortions and instabilities which they introduce are not to be excessive.

For example, in the New York–Los Angeles circuit referred to earlier, there are employed over 200 vacuum tubes; about one-half of these are used when the man in New York speaks to the man in Los Angeles and the other half are called into play when the Los Angeles man replies. Altogether there are, say, 25 times as many tubes in the circuit as in a good radio set. The failure of any one of these tubes would interrupt the conversation. The likelihood of burning out or sudden failure from any cause should therefore be only one twenty-fifth as great for each of the tubes used on the telephone cir-

cuit as for each of those in the radio set, if the circuit is to be at least as reliable as a radio set. Of course, an effort is made to avoid service failures of the tubes on the telephone circuit by regular tests and inspections, but long tube life is neverthe-

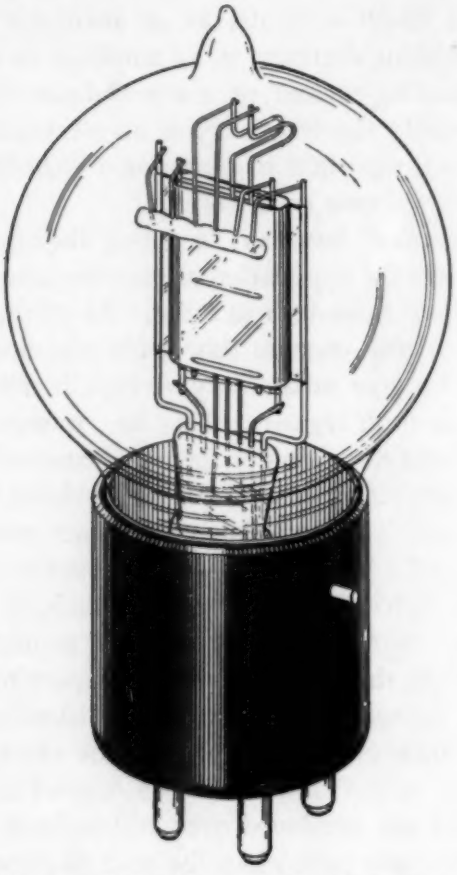

FIGURE 3. 101 F VACUUM (TYPE "L") TUBE.

less of vital importance to this end. For this reason the vacuum tubes for telephone use are designed to have average lives which are much longer than those usually considered necessary for other services. The present L and V tubes have average lives in the Bell System Plant of about 18,000 and

70,000 hours (two and eight years) continuous use, respectively, and this in spite of very rigid requirements for determining when a tube must be replaced. The average life of the tubes used in radio receiving sets is only a small fraction

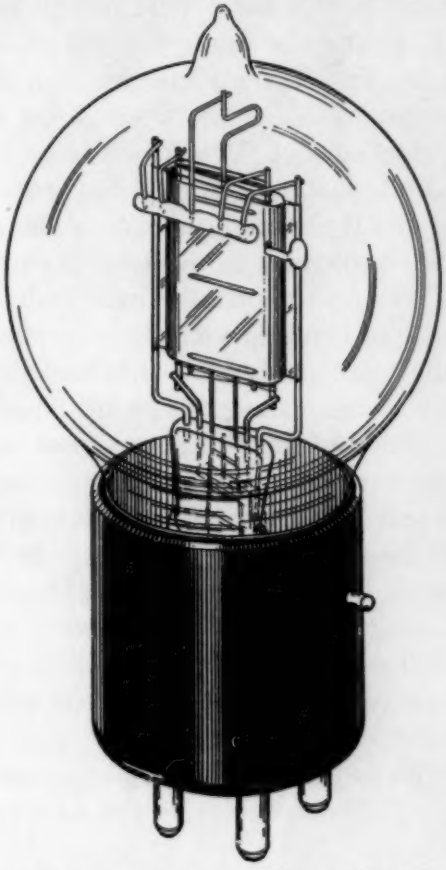

FIGURE 4. 102 F VACUUM (TYPE "V") TUBE.

of these figures, taking into account that radio sets are used only a part of each day.

Not only is long life desirable but the amplification of the tubes must be very stable. It must not fluctuate greatly when the batteries which supply the power to the tubes vary, or for

any other reason. The importance of this is evident when it is realized that the overall attenuation of a long circuit is a small margin between two very large quantities—the attenuation of the bare wires and the total amplification supplied by the vacuum tube repeaters. The New York–St. Louis four-wire cable circuit, which forms part of the circuit between New York and Los Angeles referred to earlier, is a little over 1000 miles in length. The attenuation of a 19-gauge cable pair of this length would be enormous if not equipped with telephone repeaters—about 500 decibels in engineering terms. This amount of attenuation is beyond comprehension. It has been computed that if the whole amount of energy radiated by the sun could be converted into an electrical current of audible frequency and transmitted into the cable pair at New York, not a sound would be heard in a telephone receiver in St. Louis, even though the cable pair could withstand the abuse. Yet by placing every 50 miles along this circuit telephone repeaters having a total combined amplification almost equal to the attenuation of the bare wires, the effective overall attenuation of the circuit is reduced to only a few decibels so that a whisper in New York is made audible in St. Louis. It is evident that if the overall result is to be stable, the total amplification must be even more stable. The working margin is not only small, but it must remain steady within limits which are still smaller if crosstalk, noise, echoes, or repeater overloading are not to impair unduly the use of the circuit. It is obvious that this imposes the requirement of a high degree of stability on each of the vacuum tubes contributing to the total repeater amplification.

Similar considerations apply with regard to the necessity of not permitting the tubes to distort the transmitted voice appreciably. Vacuum tubes not very far short of perfection are evidently needed if as many as a hundred tubes are to have opportunity to affect the voice currents in succession along a circuit without finally distorting the voice so as to make it

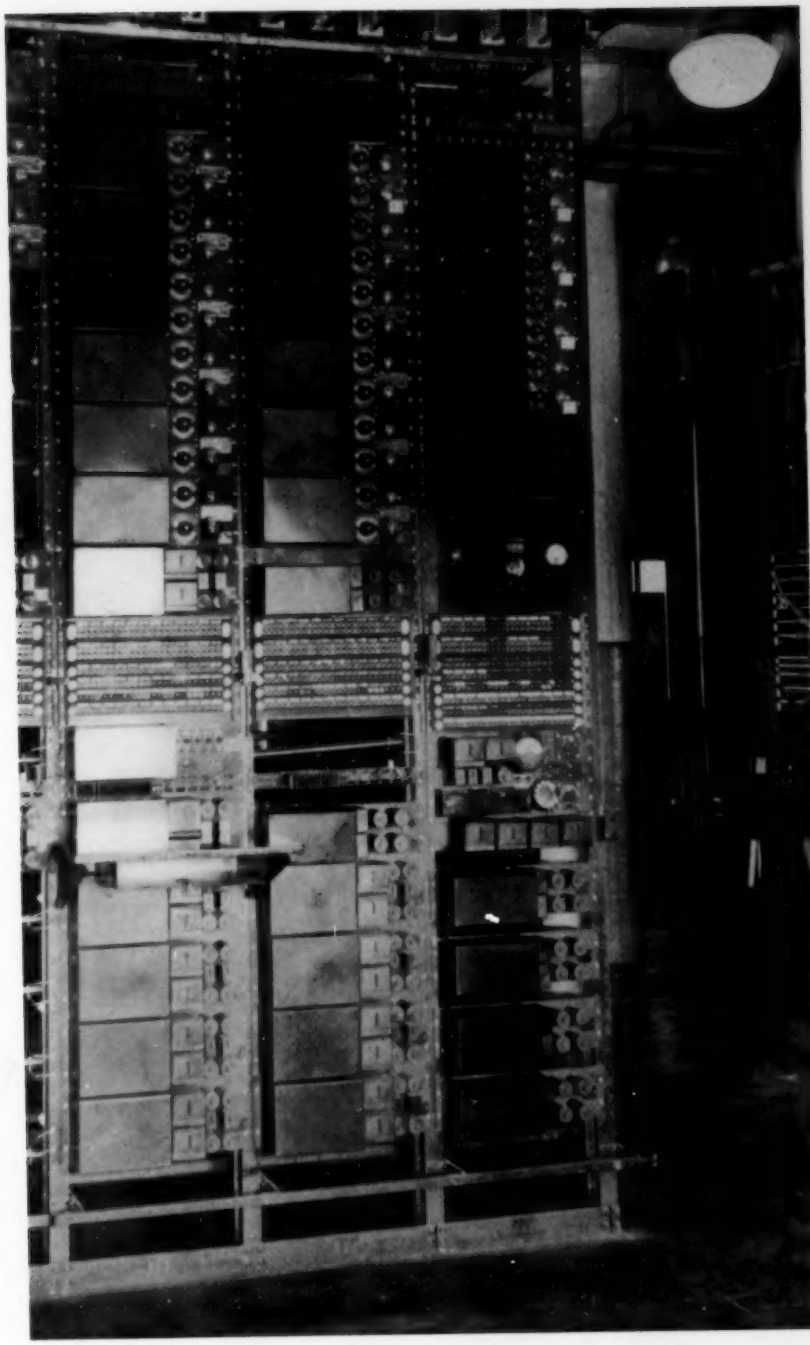

FIGURE 5. A GROUP OF TWO-WIRE TELEPHONE REPEATERS WITH ACCESSORY EQUIPMENT.

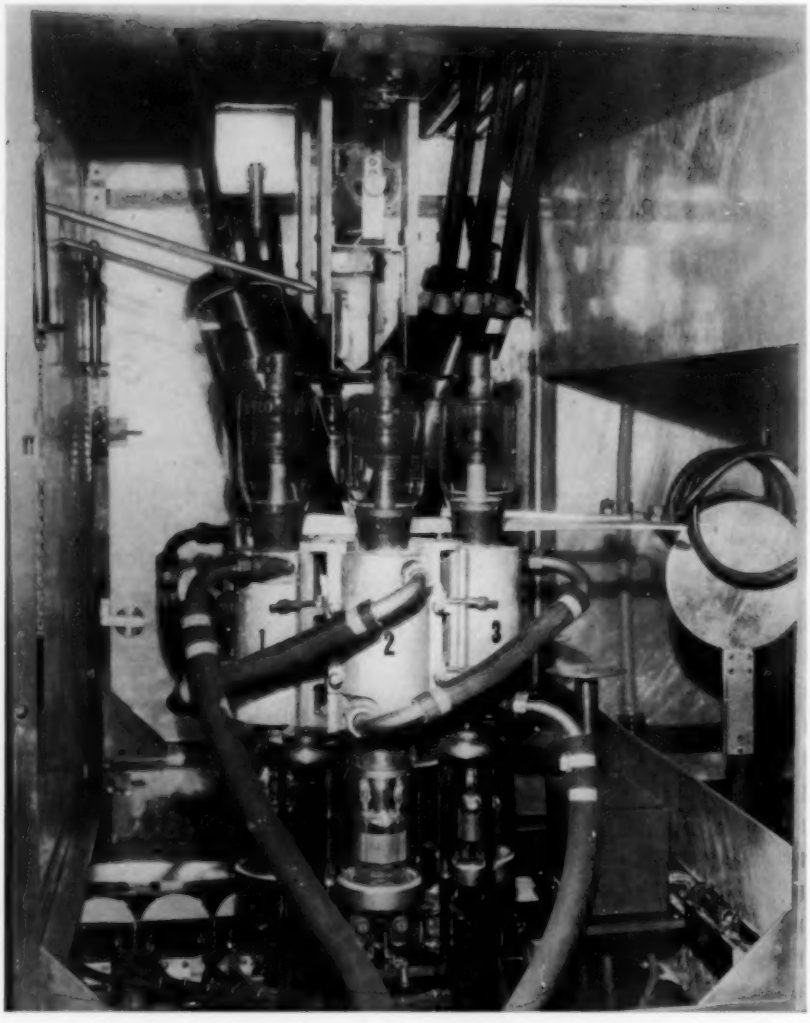

FIGURE 6. GROUP OF SIX 10 KILOWATT TUBES IN SHORT WAVE RADIO TRANSMITTER AT LAWRENCEVILLE, N. J.

unrecognizable or unintelligible to the listener. Of course, only a few circuits are as long as the New York–Los Angeles circuit but many of the shorter circuits must be of sufficiently high grade to be used, when needed, as parts of longer built up connections.

As mentioned earlier, the general types of tubes which are most common in telephone plant have existed since the very first. That is, their general electrical characteristics and even their appearance have not greatly changed through the years. In performance and economy of operation, however, the vacuum tubes of today differ as greatly from the tubes of 10 or 15 years ago, as do automobiles of those same respective periods, thanks to the development work which has been carried on by Bell Telephone Laboratories.

The vacuum tubes in use 10 or 15 years ago had average lives of less than one-tenth of the average lives of the present tubes and consumed several times as much power. These tubes, in turn, were almost as great an improvement again over the first tubes of about 1914. The average cost of keeping a vacuum tube socket supplied with tubes and with power would be increased about $33 per year if the tubes of 10 or 15 years ago were used in place of the modern tubes, and over $200 per year if the very earliest tubes were used, even when it is assumed that the price of the older tubes is based on present manufacturing costs, rather than the higher costs that prevailed in their day. The growth in the vacuum tube plant has no doubt been partly in response to the improvements which have been made in the tubes, but if it could be imagined that the present size of plant had to be operated with the old time tubes, the operating expense of the Bell System would be increased nearly $12,000,000 per year by the use of the tubes of 10 or 15 years ago, and by a much greater amount by the use of the 1914 tubes.

Looking ahead, it appears evident that the fields of usefulness of the vacuum tube to the telephone are far from exhausted.

Further developments are expected to increase to a still greater extent the economy of operation of the tubes. New types and improved designs are bringing about the possibility of obtaining new results in their use or of obtaining the same results with fewer tubes or simpler circuits. So it will not be surprising if the vacuum tube continues to find increasing application, not only to the problems of long distance telephony, but also to those of the local plant in metropolitan and suburban areas.

D. K. GANNETT

The Development of the Western Electric Audiphone

GENERATIONS of music lovers have come away from concerts uplifted by the great chorus of joy in Beethoven's last symphony; but saddened by the knowledge that much of the mighty work remained forever unheard by its creator. Certain it is that the astonishing "mind's ear" which enabled Beethoven to conceive his later compositions never fully compensated him for his loss of hearing. To his dying day he remained pathetically ready to be duped into purchasing the miserable tin funnels and "ear trumpets" that passed for hearing aids a century ago.

Today we know that an ear trumpet would probably have to be built with an opening about twenty feet in diameter in order to admit enough sound to restore Beethoven's hearing, and that such a horn would dissipate almost all of the high pitched sounds before they reached his ear. Fortunately the same researches that have given us this information have given us better means for aiding the hard of hearing. Were Beethoven listening to his Ninth Symphony today, his identity would probably be revealed more by his pugnacious face than by the inconspicuous electrical instrument that enabled him to hear his work.

Investigations along two lines have combined to produce this instrument: development of improved apparatus for electrical communication, and research in speech and hearing. Experience in Bell Telephone Laboratories has shown that the growth of one body of knowledge is almost indispensable to the growth of others. Improved instruments provide new data relating to speech and hearing, and the new data make possible the design of instruments yet further improved. It

is altogether logical that the growth thus engendered, with better telephone instruments as its principal fruit, should also afford better equipment for aiding the hard of hearing. There is obviously a close alliance between the problems of enabling those of normal hearing to hear at a great distance, and of enabling the hard of hearing to hear at a short distance. The Laboratories have systematically applied results achieved in the solution of telephone problems to the improvement of instruments for those who hear with difficulty.

The main outlines of our knowledge of hearing have been far harder to come by than they are to tell. It has been found that the normal human ear has tremendous ranges of auditory response. It is sensitive to pitches ranging in their frequency of vibration from about sixteen vibrations per second to about 15,000 vibrations per second. In the most important part of this range, between 500 and 2000 cycles per second, the ear will respond to sounds varying over an extremely wide range of intensities. When the intensities of sounds are measured by the amounts of energy they contain, the range of energies to which the ear is responsive is found to have the almost unbelievable dimensions of one hundred million million to one. This range is bounded at the lower level by the intensity of sound that is just audible, and at the upper by the intensity that causes pain.

When a person is hard of hearing, the lower boundary level is higher, so that sounds must be more intense to be just audible. Ordinarily the amount by which this threshold is raised differs at different pitches and for different people, according to the nature and severity of their hearing ailment. Thus the diminution of a patient's hearing acuity cannot be measured by a single number; a table of numbers, or a diagram of such a table in the form of an "audiogram," must be used, specifying the amounts by which the threshold is raised at various pitches.

This rough description of hearing loss will make clear what is required to aid those who suffer from it. The sounds reach-

ing their ears must be raised in intensity the same amounts as their auditory thresholds. Ideally this amplification should vary, throughout the pitch range, with the patient's audiogram. Since equipment especially designed for each patient would be impracticably bulky and expensive, it is better to design an audiphone that will give the best results in most cases.

The primary object of an audiphone is to amplify the sound reaching the ear of the deafened person by an amount that will offset his loss of hearing, and hence some part of any hearing aid must have this amplifying ability. The simplest and least expensive device suitable for this purpose is a variable-resistance transmitter—fundamentally the same as the carbon transmitter universally adopted for telephone use. In such a transmitter a small amount of power in the form of sound releases to an associated receiver a much larger amount of power from a local source of electrical energy. If the transmitter is sensitive and the receiver connected to it is efficient, and if both are well designed, the sound delivered to the ear will not only be a fairly faithful copy of that reaching the transmitter, but will also be materially amplified in intensity. The simplest form of audiphone, therefore, requires only two transmission instruments; a sensitive transmitter and an efficient receiver, of good design.

The amplification that can be obtained with this simple form of audiphone, however, is limited, and is often inadequate to compensate for a serious loss of hearing. When the earliest electrical hearing aids were designed in Bell Telephone Laboratories, it was believed that the additional amplification needed could best be secured by vacuum tube amplifiers. Several such sets were manufactured on a commercial basis, and their use over a period of years provided valuable practical information with which to determine the requirements for a thoroughly satisfactory hearing aid. Assisted by this information, and by improvements which had meanwhile been effected in allied

apparatus, further development yielded the present commercial forms of Western Electric audiphones.

It proved feasible to utilize again the amplifying ability of a carbon transmitter in providing a mechanical amplifier which increases the output about a hundred times, an amount equivalent to one stage of vacuum tube amplification, without adding materially to the size or weight of the audiphone. The new Western Electric audiphone, therefore, consists essentially of the three elements shown in Figure 1: a new transmitter and receiver, and an amplifier of the sort just described. The transmitter, at the left, is less than 2½ inches in diameter, and the receiver at the right, which weighs less than ¾ ounce, is only ⅞ inch in diameter. These small dimensions are only the most conspicuous of the many advantages provided by the special design of the transmitter and receiver.

The audiphone, furthermore, gives the sufferer from impaired hearing almost all the auditory experience he has. He depends entirely upon its fidelity, and it is important that he receive a high grade of service. The transmitter is accordingly specially designed to minimize erratic transmission, carbon noise and carbon aging. The receiver contains an electromagnet, supplied with magnetizing current by the same battery that supplies current to the transmitter and the amplifier. After the receiver has been assembled, the pole piece of this magnet is adjusted to such a position, relative to the receiver diaphragm, that the receiver as a whole will have maximum efficiency and is then sealed in place.

The amplifier is the most unique element in the audiphone. As has already been pointed out, it consists of two parts, similar respectively to the receiver and the transmitter. The electrical output from the audiphone transmitter passes through the winding of the receiver part. This varies the magnetic field in the air gap of the magnetic circuit, whose metallic portions are of permalloy, and so causes a permalloy diaphragm to move correspondingly. The permalloy diaphragm drives

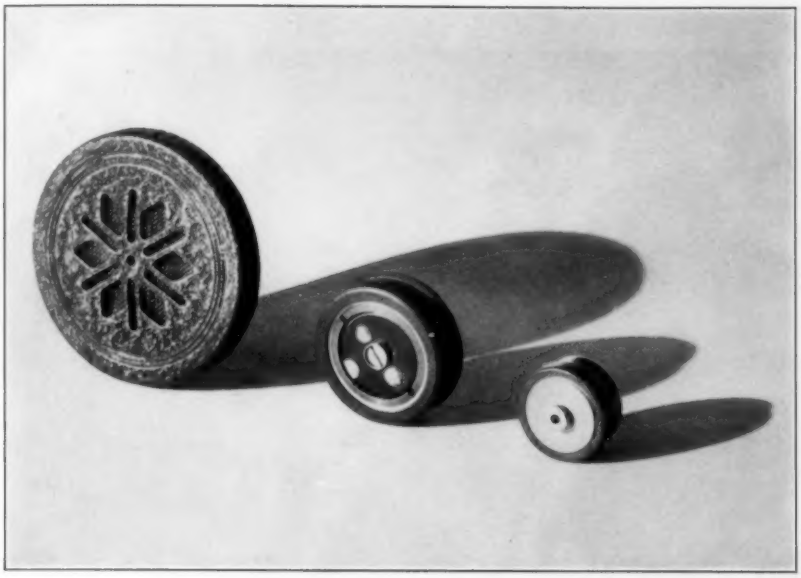

FIGURE 1. TRANSMITTER (LEFT), AMPLIFIER, AND RECEIVER (RIGHT) FOR THE NEW AUDIPHONE.

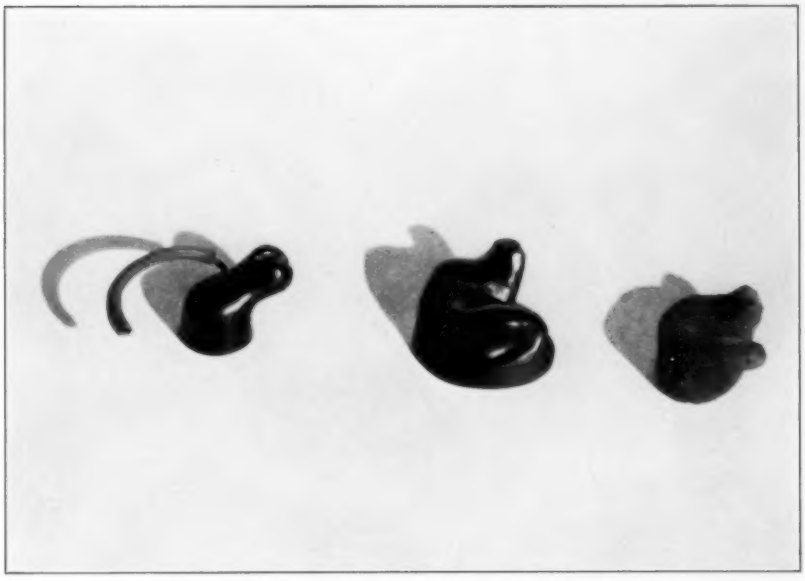

FIGURE 2. THE OLDER UNIVERSAL TYPE OF EARPIECE, ON THE LEFT, MAY BE ADJUSTED TO CONFORM TO THE EAR, WHILE THE INDIVIDUAL TYPE, IN THE CENTER, IS SPECIALLY MOULDED FOR EACH USER. UNIVERSAL EARPIECES OF SOFT RUBBER ARE ALSO AVAILABLE IN FOUR SIZES, OF WHICH ONE IS SHOWN AT THE RIGHT.

FIGURE 5. STILL ANOTHER ALTERNATIVE ARRANGEMENT IS PROVIDED BY THE 12A CARRYING CASE WHICH ASSEMBLES THE COMPLETE 38A AUDIPHONE AND BATTERY IN A SINGLE UNIT.

a copper diaphragm of similar dimensions through an air coupling formed by the narrow air space between the two. The copper diaphragm acts on the granular carbon as does the diaphragm of a transmitter, and produces the desired amplification. The amount of amplification can be adjusted by a rheostat in the circuit.

The final step in transmission, from receiver to ear, is accomplished by the earpiece, which is made so that it can be rigidly attached to the receiver and closely fitted into the ear. Of the three types available, shown in Figure 2, one is individually moulded to fit the ear of a single user, and the others are universal types. The older universal earpiece, of hard rubber, is made in four sizes and can be adjusted to fit the important dimensions of any user's ear. The new universal earpiece is made of soft rubber and also in four sizes, one or another of which will fairly satisfactorily fit almost any ear. The individual type is preferable to either of the others, because it distributes the pressure uniformly on the ear, whereas the universal types must concentrate a certain amount of pressure to prevent acoustic leakage around the earpiece.

The commercial sets embodying this apparatus are made with two different groupings of the elements. With one, in which the transmitter is separate and the rheostat and amplifier are combined, the transmitter may be worn inconspicuously and the combined rheostat and amplifier may be placed in the pocket. In the other, maximum compactness has been achieved by combining transmitter, amplifier and rheostat in a single unit (Figure 3). In both these sets the battery is kept separate so that either a battery box with standard flashlight cells or a special audiphone battery can be used. For use with the more compact set, there is a carrying case which will accomodate the battery also.

A third set is made without an amplifier for those whose hearing is not greatly impaired but who do require some aid (Figure 4). Ordinarily even these people, however, find it

valuable to have the greater flexibility of volume range provided by the greater amplification of the other sets.

The transmitter for these sets has an attractive geometric design on the face and is finished in a blue-gray crinkle lacquer which blends well with almost any color and fabric. A clip on the back makes the transmitter as easy to attach to the clothing as a fountain pen. Of the set without amplifier there remain to be concealed only the rheostat and the battery, both of which will readily fit in a pocket. For the sets with amplifiers, the containing cases are comparable to cigarette cases in size, and are finished like the transmitter in blue-gray crinkle lacquer. The carrying case for the compact audiphone contains the entire equipment (Figure 5); the instrument can either be used in the case or worn on the person.

Even the minor elements of these sets have been designed with great care. Thus the twisted cord used in earlier models has been replaced by very small "concentric" cord, which is easy to handle, consisting of an insulated flexible conductor, around which another conductor is woven in the form of a cylinder. So effectively have the size and weight of all components been reduced that the compact set, including three flash-light cells which weigh about a pound, weighs less than a pound and three quarters, and can be so disposed in use that practically nothing is noticeable but the small receiver and part of its connecting cord.

Interesting considerations arise in the attempt to rate the value of the new audiphone. Because of the large number of factors contributing to one's ability to understand speech, the value of a hearing aid is difficult to determine. Experience has shown that the most satisfactory way is to make a test to determine the percentage of typical sentences which can be understood. In applying the test, the user of the audiphone is seated about three feet from a speaker who reads in a conversational voice a number of sentences such as "Fire insurance is desirable; Washington was called the father of his country;

it is dangerous to throw away a lighted match." From a record of the number of statements understood with and without the audiphone, the usefulness of the audiphone can be measured.

The case of Mr. A illustrates that many precautions must be taken in interpreting these results. When ten sentences are addressed to Mr. A without the audiphone in use, he understands only two completely, although he hears snatches of others. He is then requested not to watch the speaker, and of the next ten sentences he fails to understand any, although again he hears parts of several. Apparently Mr. A has some lip-reading ability, although he may be unaware of it. Mr. A again watches the speaker, the test is continued with the audiphone, and he quickly and correctly repeats every sentence.

Mr. A hears so well with the new audiphone partly, of course, because of its careful design, but his history helps the audiphone to give him so much satisfaction. By using a hearing aid for years, he has kept his ears in an environment of speech—always interpreting through hearing regardless of distortion. He does not have to learn again to interpret through his ears. Someone else, who has an identical hearing loss but who has withdrawn from contacts where he must depend on hearing, may not be able to obtain so much aid from the audiphone at first. As he uses it, however, he will become increasingly proficient in interpreting what he hears, and the audiphone will give him more and more satisfaction.

Mr. A's test is not hypothetical, it is one of many that have been made with the new audiphone. Some of those tested have had only moderate hearing losses; others have had very little useful hearing range. The results obtained with the audiphone have varied correspondingly, but very few people have been found whose hearing loss was so great that they were not able to carry on conversation with the help of the new audiphone.

The tragedy of Beethoven's deafness is but a private tragedy

come to public notice. Thousands of similar tragedies have been no less acute because less renowned, for each man's enterprises are as important to him as Beethoven's were to the world. Past years have each claimed a quota to be debarred from travelling one of the main avenues to life's experiences. It will gratify members of the Bell System to know that its studies of the needs of these sufferers have enabled it to swing back the ancient barrier.

A. N. HOLDEN

The Growth of America's Communication Needs

IT is scarcely a coincidence that both the telegraph and the telephone were invented in America. It is certainly no accident that the art of electrical communication has had its greatest development in the United States. With a pioneer people thinly spread over a continent, the need for communication was imperative. From this need came the urge to invent, the urge to develop. The changing frontiers of American life and two inventions that themselves were on the frontiers of science were, to a large degree, cause and effect.

Widely diversified in soil and climate, in mineral wealth and in industrial or commercial opportunities, the original colonies early established trade relations for the interchange of necessaries, thus setting up the economic basis for communication facilities. Families moved from one section to another, leaving relatives and friends behind, a separation which formed the social basis that made some form of communication desirable. Under these economic and social compulsions for communication, pathways were cut through the forests, sailing vessels skirted the coast and post riders took adventurous journeys across mountains and through streams. Life and death, as well as business success or failure, depended upon the delivery of messages, as they do today in times of emergency.

To the economic and social needs of the colonies for communication there were added political exigencies. When the colonists found themselves faced with the War of Independence, one of their first acts was the establishment of a system of postal routes, independent of those maintained by the Crown. In order that the Revolution might be carried on successfully, co-operation between the widely separated colonies was essential, and this necessitated means of communication which were

at once prompt, dependable and safeguarded against the operations of British spies or hostile Indians.

That the colonies were not at first fully awake to the importance of communication facilities as factors in their fight for liberty is evident from the fact that it required a considerable amount of propaganda to bring about the establishment of this "constitutional" postal system, in opposition to that carried on by the British government. It is on record that the establishment of what is now the United States mail service may be traced largely to the efforts of one William Goddard, a printer, who went from colony to colony urging the step. In 1775 the Continental Congress appointed Benjamin Franklin as Postmaster-General, an office he had held with distinction under a former appointment by the Crown. When Franklin sailed for France to negotiate for a treaty between that country and the newly established republic, he turned the office over to his son-in-law, Richard Bache, who served until 1782. It is interesting to note that when Franklin resigned as head of the postal system, there were only seventy-five post offices in the entire country and that the total length of American postal routes was only 1875 miles.

Washington, Communication Pioneer

The political importance of communication facilities continued for many years after the Revolution to be an increasingly vital factor in America's development as a nation. Indeed, it fell to Washington to take what was probably the first real step toward providing adequate means of contact with the more remote American settlements. Few public men of his time understood as clearly as he did how important the western territories were to the new nation or how necessary it was to provide closer ties with the Americans who had gone there to make their homes.

Washington's interest in this matter was of long standing, probably dating from his historic journey to the French forts

along the Ohio in the service of Governor Dinwiddie of Virginia in 1754. In 1770 and the two following years he made additional trips over the mountains westward as a result of which he began an active campaign for the improvement of the navigation of the James and Potomac Rivers, introducing a bill for that purpose before the Virginia House of Burgesses in 1774. The bill failed of passage, and the outbreak of the Revolution turned his thoughts, like those of all of his countrymen, toward war.

When Washington returned to Mt. Vernon at the close of hostilities, his attention again was focused upon the project which had been dear to him before the conflict. On September 1, 1784, he left for a trans-mountain tour in order to obtain further data regarding conditions and requirements. He traveled more than 600 miles, on horseback and on foot, and returned with a report, filed with Governor Harrison, of Virginia, that included the first general outline of a system of public improvements in the history of the country.

Citing conclusive facts to prove the importance of the western territory, he hinted that, without adequate means of communication, the settlers beyond the Alleghenies were likely to be drawn in their economic interests, if not in their political allegiance, either to the British on the north or to the Spaniards on the south.

"The great object," he wrote to Edmund Randolph in 1785, "for which I wish to see the navigation of the Rivers James and Patomack extended is to connect the Western Territory with the Atlantic States; all others with me are secondary."

It is interesting, and of considerable importance as bearing on the later development of communication and transportation in America, to note that the project in which Washington was chiefly interested—the improvement of the navigation of the Potomac—was undertaken, not as a public but as a private enterprise. Virginia and Maryland having enacted laws authorizing the organization of a company for the improvement

of the Potomac River, subscription books were placed in the various towns of these two states, and when these were opened, on May 17, 1785, it was found that a total of 403 shares had been subscribed, for a total of £40,300.

The policy of financing improvements in transportation and communication as privately-owned enterprises, rather than as public projects, thus early inaugurated, has been very generally adhered to throughout American history. With a few exceptions, such as the National or Cumberland Road, the facilities which have been created to meet America's growing communication requirements have been inspired by private initiative and carried to completion by private capital. It was thus that most of the nation's turnpikes and canals were built and all of its railroads constructed. So, too, years later, when Morse invented the telegraph and Bell gave the world the first telephone, it was private enterprise and the investment of private funds that developed these inventions into the far-reaching systems of communication they now are.

Among those who blazed the trail for this extensive development of communication facilities, one of the foremost was Washington. Because of his interest in internal improvements, he has been called America's first expansionist. Certainly he was among the first of Americans to see that all true expansion must be based upon the provision of adequate facilities for transportation and communication. Simple as this seems, it was to become the issue of many a heated political conflict before the nation had reached full stature.

An Era of Territorial Expansion

When the question of the Louisiana Purchase was before the United States Senate, Senator James White of Delaware, while approving the acquisition of New Orleans and such other ports on the Mississippi as were necessary to open the river for navigation, declared that "as to Louisiana, this new, immense, unbounded world, if it were ever to be incorporated into this

Union, which I have no idea could be done except by altering the Constitution, I believe it would be the greatest of curses that could at present befall us."

He further contended: "Louisiana must and will be settled, if we hold it, and with the very population that would otherwise occupy part of our present territory. Thus our citizens will be removed far from the capital of the Union, where they will scarcely ever feel the rays of the general government; their affections will become alienated; they will gradually begin to view us as strangers; they will form other commercial connections and their interests will become distinct."

Even so clear-eyed an explorer as Lieut. Zebulon M. Pike, who headed two expeditions into the prairies west of the Mississippi and far into the hills and mountains beyond them, could see but a single advantage in these vast stretches of "desert" —that of preventing the further spread of population over the west.

"From these immense prairies," he wrote, "may be derived one great advantage to the United States, namely the restriction of our population to some certain limits, and thereby the continuation of the union. Our citizens being so prone to rambling and extending themselves to the frontier will, through necessity, be constrained to limit their extent to the west to the borders of the Missouri and the Mississippi, while they leave the prairies, incapable of cultivation, to the wandering and uncivilized aborigines of the country."

But the propensity toward "rambling and extending themselves to the frontier" urged Americans westward in waves of population, over sands, rivers, prairies and mountains, until they had reached the Pacific. Every movement of settlers created its own political problems and these, in turn, created problems of communication and transportation.

As late as the days of the Oregon controversy, when railway transportation in the east was well under way, statesmen seriously debated the question whether it was worth while to

lay claim to the territory, because of its remoteness and the apparent impossibility of maintaining adequate communications between it and the eastern sections of the Union. One legislator declared that it would take a representative from that part of the country a year to make the round-trip journey to Washington, while Webster himself heatedly affirmed that he "would not vote one cent from the public treasury to bring the Pacific coast one inch nearer to Boston than now."

The conservatism of executives and legislators did not, however, stay the onrush of settlers to the West. Marcus Whitman, missionary and practical patriot, had taken a wagon over the Rockies even while pessimists were solemnly asserting it could not be done. Gold was discovered in California with consequences known to everyone. Homesteads began to dot regions hitherto known only to trappers. Towns sprang up where there had been only virgin forest or unobstructed plain. The Empire of the West was in the making.

But this advance of the borders of settlement was made possible only by the establishment of lines of communication with the eastern and southern bases from which these armies of settlers had moved. Covered-wagon trail, Pony Express route, railway, telegraph and telephone in turn played vitally important parts in the winning of the West. It is hardly too much to say that, from the standpoint of political unity, this vast expansion would have been impossible in the first place without communication ties binding section to section. If it had been possible, it could have been accomplished only with the gravest danger to the integrity of the Union.

A Nation of Many Tongues

Meanwhile the need of communication had become important for another reason. Immigrants from Europe were pouring into the United States in increasing numbers. They were people of many tongues and races. Their assimilation soon became a problem. No physical frontiers now separated them,

race from race, as often had been the case in their homelands. Here they were neighbors. Each with his own racial characteristics, traditions and antipathies, they were forced to find common ground upon which to unite as Americans. Without communication, they might have withdrawn, each group to its own section of the country, to perpetuate in a new land the disunities of the old.

The admission to the Union of states which had originally been settled by non-British also presented a social and political problem which gave added importance to the development of communication facilities. Many of the pioneers of Louisiana were French, many of those in Florida and in sections included in the territory obtained from Mexico were of Spanish origin. If anything like a national consciousness was to be brought out of this addition of territories and states with dissimilar human ingredients, there had to be dependable and reasonably prompt means of communication between one section of the country and the others. Without such facilities for exchanging ideas, the expansion of the country would have been the making of a political patchwork, each part with its individual racial and political background and its own language and traditions.

To many students of American history it seems providential that, at the very moment when this remarkable spread and heterogeneity of population was beginning to assume full momentum, Morse should have begun experimenting with an instrument which was later to become the electric telegraph. It is a striking coincidence that his first message should have been sent over the first telegraph wire at the very moment when there arose in the United States the greatest need for communication facilities.

The telegraph lines soon began to creep westward. In less than two decades they had reached the Pacific. As the coming of steel and steam and the development of the railway postal service had been followed by an accelerated movement of population toward the setting sun, so the advent of the telegraph was

a signal for a further quickening of pace in the march of civilization across the continent.

The provision of the new communication facilities made possible by the development of the railway postal service and the telegraph, moreover, had another effect than that of merely increasing the numbers of those who turned their faces westward. Puffing locomotive and clicking telegraph were potent factors in attracting to this land of wider horizons a new type of men and women.

When the only ties with the East were trappers' trails or the wheel-marks of infrequent prairie schooners, a large percentage of those who set out for the West was made up of men—and women, too—in whom a spirit of romantic adventure was an almost universal characteristic. With the advent of the railway and telegraph, even the less hardy souls, who had hesitated to isolate themselves in these remote western regions, began to answer the call of new and alluring opportunities. Hamlets grew into villages, which in turn became bustling "boom towns" and, eventually, cities. In the wake of the adventurers came the homemakers, the builders of industries, the creators of states. Railroad and telegraph communication with the East helped to assure to these western regions an influx of newcomers who, if they lacked some of the spectacular daring of those who had blazed the first western trails, had qualities which contributed greatly to the making of America.

Changing Economic Conditions

While these western migrations were taking place, there were occurring changes in national economic conditions that were destined to play important parts in making necessary the network of telegraph and telephone wires that now crisscross the continent.

Despite the exodus of thousands of pioneers to newly opened territories in the West, population had begun to congest along the Atlantic seaboard, particularly at points where harbor

facilities were such as to encourage export and import trade. For some decades, America's large cities were confined to areas on or near its eastern coastline. Throughout this region generally, and in New England in particular, climate and soil were not such that these large cities could be sustained by the lands immediately adjacent to them. Foodstuffs had to be brought to them from a distance which increased as their population mounted. Transportation had to be provided in order that these necessaries might be carried from the point of production to the point of consumption. Wagon roads, canals and, finally, railroads, were built, each in response to this necessity. But the need for these facilities was not merely one for transportation of commodities. Hardly less urgent was the demand for carrying messages between these widely separated points.

Foodstuffs had to be bought and sold before they could be shipped and consumed. It was wasteful of time and energy for the buyer to go to the source of supply for his goods, or for the seller literally to carry his goods to market. Messages of one kind or another supplanted these face-to-face transactions. In conducting business negotiations, men no longer went—they sent. Communication began to be an important factor in America's internal commerce.

So with other necessaries than food. Until the development of steam and electricity, manufacturing plants were located along streams from which water-power could be obtained conveniently and cheaply, often at considerable distance alike from the source of raw materials and the market for the finished product. Out of this fact grew new requirements for better, more prompt, more dependable communication facilities. The producer of raw materials, the manufacturer, the retail merchant and the consumer had to be linked by ties which would enable each to keep in touch with the man with whom he immediately dealt—and that without stopping work. More than ever before, words became the tokens with which trade was carried on.

As larger cities were built in newly opened territories, each became the center of a new market, demanding lines of communication running back to the source from which its necessities came. If these cities were to live, they had to maintain these ties. To be decently fed and clothed and housed, people had to exchange messages with people of other regions.

Rising Standards; Wider Markets

For a multitude of economic reasons, America became a land of rising standards of living. Each generation lived more comfortably than that which had preceded it. The luxuries of one decade came to be looked upon as the necessities of the next. To the four corners of a continent rich in widely diversified resources Americans sent for those things which they ate, with which they clothed themselves, or with which they built their homes. Trade was no longer confined to transactions in what had once been looked upon as necessaries. As the diversity of products increased, so also did the volume. The era of quantity production had its origin in the demands of a growing nation and in living standards that were mounting higher and higher. Every addition to commercial activity augmented the demand for more widespread communication facilities.

The development of quantity production by manufacturers, mine operators, farmers and lumbermen brought about a production policy which in America has reached a point equalled nowhere else in the world. This policy of quantity production soon made it necessary to reach out continually for wider markets. Modern methods of manufacture also have called for the establishment of branch factories in many widely separated parts of the country. Sales organizations, too, have covered the country from coast to coast. The profession of advertising has contributed an important part toward the creation of new wants and new markets. Every one of these developments would be impossible without adequate systems of communication.

The past half century in America, then, has been an era of ever-increasing demands. The descendants and successors of the restless, adventurous pioneers who first settled the country have been impatient of any kind of limitations. Because Americans have wanted so many things, and have insisted on getting them, America leads the world in the development of electrical communication facilities. One's wants cannot be satisfied unless they are made known. When they are to be satisfied from a distance quickly, they must be made known quickly. Prompt communication is as important a factor in meeting these wants as is transportation.

A Prophetic Telephone Message

At about the same time as the beginning of this period of America's enlarged social and economic demands, Alexander Graham Bell spoke over the first telephone line the first sentence of speech transmitted electrically. That sentence was: "Mr. Watson, come here, I want you." It was as if this young Scotch-American had voiced a prophecy to be realized even during his own lifetime, when the telephone, thus brought into being, would become an instrumentality of expressing the wants of America. It was as if he had foreseen the day when one American, anywhere within the borders of the country, could call out to another American, anywhere: "I want you. I want the things you have—the goods you have to sell; your market for my products; your skill as a professional man; your assistance as a protector of life and property; your word of counsel or sympathy as a friend."

Americans have wanted these things; have demanded the facilities which would make it possible to express these wants, and to express them quickly, over vast distances. Out of this demand have grown America's communication systems. Not otherwise could these networks of wire be created, nor the demands met.

R. T. Barrett

Certain Significant Features of the Census of Distribution

THE Census of Distribution[1] taken in 1930 by the Federal Government constituted a new venture in census-taking, undertaken in response to an expressed need for definite information on this phase of American economic life. Statistics of the productive industries—agriculture, manufacturing, etc. —had been regularly assembled in each decennial census (or more frequently), but only in the last decade had the problems involved in the moving of goods from producer to ultimate consumer become sufficiently pressing to call for the collection of a body of data relating to the whole distributive process.

The census furnishes an immense volume of facts on both wholesale and retail trade: dollar sales, number of establishments, types of business organization, business expenses, etc., for a detailed classification of kinds of business, by states and for the largest cities; wholesale data are reported in less detail for counties and for all places of 5,000 population and over; figures on retail sales and number of stores are also reported for all places of more than 1,000 inhabitants and for counties. With all this information available for the first time, the census material will be found highly useful both to those engaged in the business of distribution and to those who regard the distributive field as a market for their services or who have services to sell directly to the ultimate consumer. Any light it can shed on the economic life of the country, and whatever value or limitations the data may have as a measure of potential markets, are of inherent interest to the telephone industry.

It is, of course, inevitable that the data should have their limitations. Because it was a new type of inquiry there were

[1] The early reports of this census were analyzed in an article by R. L. Tomblen in the BELL TELEPHONE QUARTERLY for October, 1931, "Preliminary Returns of the Distribution Census."

difficulties of classification and lack of proper records from which to furnish information; because the census was taken on the basis of establishments, certain types of businesses, particularly some of those dealing in agricultural products, were not included. Moreover, the arbitrary decisions which had to be made in classifying some establishments as engaging either in a wholesale or in a retail trade or in designating the "kind of business" under which a given firm should be placed led to some inaccuracies, with the result that all the figures must be regarded as indicating the general situation rather than as being exactly descriptive.

One thing which is at once apparent from the data is that the line of demarcation between wholesaling and retailing is not clearcut. The fundamental difference is, of course, that wholesalers are engaged primarily in the collection of goods from manufacturers or other producers and the distribution of them to retail merchants for resale, while the retailer is engaged only in the final process of distribution to the ultimate consumer. Most wholesale houses, however, have occasion to make some sales at retail, while at times retailers sell to other retailers on a wholesale basis. Furthermore, manufacturers enter into the distribution field by selling some goods directly to retailers and some to consumers. These are elements which complicate the picture of distribution and indicate plainly that a considerable share of the goods ultimately consumed does not pass along the conventional path from producer to wholesaler to retailer to consumer.

SALES MADE IN OTHER THAN THE CONVENTIONAL MANNER

Channel	Amount	Per Cent of Total Business of Seller
Manufacturing Plants to Retail Organizations	$13,009,588,000	20.5
Manufacturing Plants to Industrial and Other Large Consumers	19,849,875,000	31.3
Manufacturing Plants to Household Consumers	1,553,367,000	2.5
Wholesale Organizations to Industrial Consumers	15,003,922,000	21.7
Wholesale Organizations to Ultimate Consumers (at Retail)	689,817,000	1.0
Sales of Retailers to Other Retailers	706,776,000	1.4
Sales of Wholesalers to Other Wholesalers	Unknown but small	

The net sales reported for 1929 by all wholesale establishments included in the Census of Distribution amount to $69,291,548,000, while the net sales by retail establishments total $49,115,653,000. If to these figures are added the $34,400,000,000 of sales made by manufacturers without a wholesaling intermediary, the $4,500,000,000 of the products of extractive industries not flowing through wholesale channels and the unknown but sizeable sales of dealers operating without fixed establishments, the total transactions in the field of distribution reach approximately $160 billion per year.[2] And of these $160 billion, about 35 per cent are sales made in ways other than those included in the popular conception of the step-by-step distributive process.

The major part of the sales directly to industrial consumers, shown in the above table, of course represents raw materials, goods partially fabricated, or equipment to be used in the further production of goods. The largest net sales, whether made by manufacturers or wholesalers, are in iron and steel and their products, machinery and other equipment, and textiles and raw cotton. On the other hand, the sales of manufacturers to retailers are mainly in various types of food products and finished textiles, and over 50 per cent of those to household consumers are in food products. One-third of the retail sales by wholesalers are in automotive products, and the same proportion holds for the sales by retailers to other retailers. This last item is largely sales to used-car dealers of automobiles accepted as part payment for new cars.

Distribution activities engaged over 7,000,000 people in full-time occupation in 1929 and nearly another 700,000 in part-time work. Together these groups made up almost 16 per cent of all those gainfully occupied in the United States.

[2] It should be borne in mind that all figures in the census relate to conditions in 1929.

Wholesale Trade

Wholesale trade is highly concentrated. Five-sixths of the total sales in 1929 were made in 127 counties in the United States, while one-sixth was distributed among the remaining 2,947 counties. This fact acquires added significance when it is realized that these same 127 counties accounted for only slightly more than half the retail sales and that only 41 per cent of the country's population lives in them. These counties are essentially urban in character and include most of the cities of the country which have 100,000 inhabitants or more. Over 75 per cent of the total wholesale business was transacted in such cities, and 57 per cent of the total in those located in the area east of the Mississippi and north of the Ohio and Potomac rivers.

The trade in certain commodities is even more heavily concentrated. The sales of industrial machinery, equipment and supplies, for example, are made chiefly in the industrial northeast and in such isolated industrial areas as exist in Texas and California, as are also sales in metal products to be further fabricated—iron and steel, copper ingots, etc. On the other hand, the sales of food products and groceries are much more closely related to the general distribution of the population.

The census classifies as wholesalers, in addition to wholesale merchants and manufacturers' sales branches, agents and brokers who frequently do not actually take title to the goods they buy and sell, co-operative sales agencies, chain store warehouses distributing only to their own retail stores, wholesalers who also do some manufacturing, as well as the assemblers and country buyers of agricultural products, and some other less important groups. The type of wholesaler varies, to a large extent, with the type of commodity handled. Nevertheless, the "old-line" wholesale merchant holds a dominant position, having transacted 36 per cent of all the wholesale business in 1929 and being represented in almost all lines of trade. The

principal types of wholesalers and the lines in which they do their largest volume of business are as follows:

	Per Cent of Total Wholesale Trade	Principal Lines of Business
Wholesale Merchants	36	Generally Represented
Manufacturers' Sales Branches..	21	Meat Products, Coal, Machinery
Agents and Brokers.....	21	Farm Products, Food Products
Country Buyers and Assemblers	7	Cotton, Grain, Tobacco

The pattern of the wholesaling process has become more and more complex as new methods of distribution have been introduced to meet the changing conditions of modern business life. Chain store warehouses, for example, have assumed importance as chains have increased their proportion of the retail business, especially in the groceries and food specialties, dry goods, and drug lines. Others known as "cash and carry" wholesalers, wagon distributors, and mail-order wholesalers are now doing a business which is a small part of the total trade, but which is an indication of the efforts being made towards reducing the cost of distribution by curtailing some of the usual services.

Expenses in Wholesale Trade

The expense of carrying on a wholesale business is an important element in the final cost of commodities to consumers. The relative cost as a proportion of the net sales (cost including total salaries and wages, salesmen's expenses, rent paid, interest on borrowed money and incidentals) varies with the volume of business, the type of commodity handled, etc. For the country as a whole, the relative costs among wholesale merchants as a class decrease consistently as the volume of net sales increases; this also holds true for dealers in all the 24 general kinds of business listed by the census except for minor variations, as is shown in the accompanying table. The ratio of expenses to sales is on the average 64 per cent lower among concerns with average sales of $1,000,000 or more than among those with sales of $25,000 or less. The distributors of metals

TOTAL EXPENSES AS A PER CENT OF NET SALES AMONG WHOLESALE MERCHANTS,* CLASSIFIED BY KIND OF BUSINESS AND NET SALES

Kind of Business	Volume of Net Sales									
	Total	Under $25,000	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $199,999	$200,000 to $299,999	$300,000 to $399,999	$400,000 to $499,999	$500,000 to $999,999	$1,000,000 and Over
Total	12.2	26.9	21.8	19.4	16.9	15.3	14.3	13.4	13.0	9.7
Amusement and Sporting Goods	23.7	46.9	32.7	32.2	25.4	25.5	23.5	22.3	24.2	17.7
Automotive	15.0	32.4	27.0	26.3	25.1	22.4	22.5	20.6	18.4	10.8
Chemicals and Drugs	16.3	37.6	30.2	24.8	22.2	22.5	20.2	15.9	16.5	14.0
Dry Goods and Apparel	13.6	21.2	17.4	15.9	14.4	13.9	14.1	13.5	13.0	13.2
Electrical	16.9	34.2	27.7	22.8	22.4	20.7	17.6	17.7	16.6	14.8
Farm Products	5.5	28.2	23.3	15.7	11.9	9.5	10.5	8.2	6.9	4.4
Farm Supplies (except machinery)	8.9	25.4	13.9	15.3	13.2	11.6	12.6	12.4	9.6	7.2
Food Products	10.5	20.7	16.5	14.6	13.1	12.0	11.2	10.1	10.6	8.8
Forest Products (except lumber)	11.3	31.1	23.7	20.1	18.8	14.5	12.6	12.7	9.4	5.5
Furniture and House Furnishings	19.0	34.8	25.7	28.9	22.1	21.6	20.0	22.2	20.7	14.3
General Merchandise	8.8	21.9	17.8	15.2	16.6	12.1	13.7	10.0	14.1	8.2
Groceries and Food Specialties	9.0	22.4	18.3	14.3	10.8	9.5	9.4	9.0	9.3	8.1
Hardware	18.8	30.2	26.9	22.0	20.8	18.8	20.7	19.6	19.0	18.3
Iron and Steel Scrap, Other Waste	12.7	26.8	20.4	18.3	16.5	15.5	14.7	14.7	13.2	7.9
Jewelry and Optical Goods	17.9	27.3	22.2	19.2	17.0	17.7	15.9	16.6	17.9	18.2
Leather and Leather Goods (not gloves and shoes)	12.2	16.6	14.9	15.1	15.8	16.4	12.7	11.9	13.1	8.6
Lumber and Building Materials (not metal)	17.2	39.1	33.1	28.0	22.7	20.4	19.5	18.8	16.9	12.9
Machinery, Equipment and Supplies (except electrical)	19.4	34.2	27.9	25.5	23.0	21.5	20.4	18.7	18.5	13.9
Metals and Minerals	7.5	32.8	23.7	19.4	17.1	15.2	11.5	14.7	11.0	5.5
Paper and Paper Products	16.6	22.8	21.2	22.1	20.6	20.4	17.8	17.8	17.4	13.7
Petroleum and Petroleum Products	14.9	21.7	16.8	16.3	17.8	18.1	16.2	18.7	15.0	13.2
Plumbing and Heating Equipment and Supplies	20.0	37.5	27.1	22.5	19.4	20.7	18.7	17.7	20.7	19.6
Tobacco and Tobacco Products	7.5	12.3	10.4	7.7	6.3	6.2	7.1	6.2	6.1	8.6
All Other	13.3	29.7	25.8	22.4	20.7	18.5	18.6	16.2	16.3	9.6

* Wholesale merchants in this tabulation include importers, supply and machinery distributors and wholesale merchants.

and metal work (except iron and steel) are an extreme example of the range in this ratio of expense to sales. Establishments in that business making an average of more than $1,000,000 annual net sales spent $1.60 for every $100 of sales, while those averaging less than $25,000 spent $37.80.

Certain types of business which are carried on mainly outside the cities of 100,000 inhabitants or more—such as farm products, farm supplies, general merchandise, etc.—have expenses which are well below the average in their relation to net sales. The apparent indication from this fact, that location in a more rural area is an advantage in this respect for a wholesale establishment, is, however, fictitious. A comparison of the relative expenses of establishments in the same kind of business located in cities of 100,000 or more with the expenses of those in other territory, in representative areas of the country, shows that in a majority of the kinds of business expenses take a lower proportion of the net sales of establishments in the cities. Evidently the saving which accompanies location in smaller places is not usually sufficient to offset the effect of relatively smaller sales per establishment, and any advantage arises more from the volume of sales and the type of goods handled than from the location of a business.

Relative expenses naturally tend to be lower in lines where the goods handled are so standardized that only small selling expense is involved or where the business has a rapid turnover. The lowest expenses among wholesale merchants are found in the case of dealers in raw silk, a commodity of small bulk with its grades standardized; in 1929 they spent an average of $1.90 for every $100 of sales. The highest average is found among dealers in toilet goods and preparations, who spent $33.70 per $100 of sales.

It should perhaps be emphasized that all these figures apply only to wholesale merchants who perform all the usual wholesale services. For various reasons, relative expenses among other groups of wholesalers are generally lower. In the case

of manufacturers' sales branches, for example, the average volume of net sales per establishment is very high, while among brokers who do not have warehousing expenses and wholesalers who offer only limited service there are fewer items to be included as expenses.

Trade Territories

The area within which concerns normally sell is of special interest to the communication industries. Whether a trade territory measures the area within which there is an effective demand for a given product or whether it merely represents the limits which present organization permits a firm to cover, knowledge of where the majority of the sales are made is useful in furthering the use of communication facilities in the sale of merchandise.

There is no means of determining exactly from the census data where the goods sold at wholesale are delivered. However, two studies of special trades, based partially on data not included in the general census reports, are now available and show for the wholesale hardware and electrical trades the market radius of firms located in 18 strategic cities in various parts of the country.

Establishments in these cities which are engaged in distributing hardware at wholesale do nearly half of the total wholesale hardware business in the country. Over half of their total business is done by dealers whose operations fall within a radius of 500 miles or, in other words, whose most distant customers are not more than an overnight trip away. In spite of the fact that these cities include the largest distributing centers in the country, only 7 per cent of the business is done by companies operating on a nation-wide scale. One-third of New York's sales are made by firms selling within a 75-mile radius and more than another third by concerns with a business either nation-wide or including an export trade. In the case of the electrical trade, the business done by wholesale

houses in these same cities (constituting 69.4 per cent of the total of such business in the United States) is even more concentrated. Nearly half is done by concerns operating within a radius of 150 miles and only 4 per cent is done by firms with a national business.

Number of Marketing Units

Considerable public attention was attracted to the growth of multi-unit businesses in retail trade during the 1920–1930 decade, but it was not generally appreciated that this type of organization was also common in wholesale trade. As a matter of fact, by 1929 multi-unit organizations had made greater inroads into the wholesale merchant's field of activity than the chain store had made into the business of the independent retailer. About 36 per cent of the wholesale establishments were parts of large organizations doing 48 per cent of the total trade, while in the retail trade only 20 per cent of the establishments were other than single-store independents and this 20 per cent made only 36 per cent of the total sales. Of the business done by the largest organizations, those with 100 units or more, 40 per cent was done by the distributors of meats and 30 per cent by petroleum companies.

Sales by Commodities

The completeness of the records kept by the wholesale trade is illustrated by the fact that, for census purposes, it was possible for the trade to report 89.1 per cent of the total net sales in the United States subdivided by commodities. Concerns handling farm products and supplies, groceries and food products—in each of which there are almost innumerable items—were able to furnish the least detail, but in all others of the 24 major kinds of business over 90 per cent, and in some cases nearly 100 per cent, of the sales could be broken down by commodities. (The census schedule provided for reports on 92 major commodity lines.)

The most striking fact brought out by the figures of sales classified by commodities is the wide choice of wholesale outlets open to a producer and the extensive overlapping of all kinds of business. In general, wholesale trade is considerably more specialized than retail, and to a large extent the sales of a commodity are concentrated within a particular line of business; but the remainder of the sales of this commodity are apt to be found scattered throughout almost the entire list of kinds of business. This is especially true of products where the average unit value of the commodity is small and where final distribution will take these products to every part of the country. This situation means, of course, that not only do producers have a wide choice of channels for their goods, but that wholesalers must face competition from many different, and perhaps unexpected, quarters. A dealer may specialize in, say, electrical appliances, equipment, and supplies. He would expect competition from other dealers of all types in the electrical trade and, in the case of some of his lines, from the automotive trade, from hardware and machinery wholesalers, and from house furnishings dealers. The census shows, however, that in addition such goods are sold by the amusement goods trade, the chemical and drug trade, dry goods and apparel merchants, the leather trade, lumber and building materials concerns, dealers in metals and minerals, paper products, and petroleum, and even by tobacco merchants.

Another phase of this tendency for a commodity to be distributed through so many different kinds of business is shown in the variety of goods handled by dealers in any one line. It seems probable that these two tendencies interact on one another, and that as dealers find competition keener in their own specialties they begin to take on supplementary lines, thereby increasing the competition to be met by dealers specializing in those lines. At least 50 per cent, and frequently a much higher percentage, of a merchant's sales are made in one class of product, but the remainder may be divided among a sur-

prising number of commodities. For example, two-thirds of the sales of the dealers comprising the machinery, equipment and supplies (except electrical) trade were sales of machinery and equipment, while the remaining one-third was divided among some 70 commodities, many of them closely related products but also including as diverse products as confectionery and soft drinks, jewelry, and stationery.

Retail Trade

The figures on retail trade reported by the Census of Distribution probably have a smaller claim to accuracy than do those on wholesale trade. The average volume of business per establishment is far smaller ($32,000 annually as against $408,000), the line of goods carried is frequently much more varied, and complete accounts are not so universally kept. Moreover, in any interpretation of the statistics, more qualifying elements must be considered. Consequently, only conclusions based upon the more general figures can clearly be valid.

The 1,543,000 retail stores in the United States in 1929 transacted a total business of $49,114,653,000. The average size of business was thus $31,827, but over 43 per cent of the stores made sales of less than $10,000 while 1 per cent made sales of more than $300,000. In general, the location of both stores and sales follows the distribution of population more closely than in the case of wholesale trade, but it is influenced, too, by a number of factors: the purchasing power of the area, the drawing power of the large and varied retail establishments in cities and their constantly increasing accessibility, the proportion of food grown for home consumption in any area, the disregard by purchasers of state lines in their choice of buying centers and the degree to which mail-order buying is in favor.

The structure of retail distribution has become more and more complex under the stress of changing market conditions; the prevailing tendency in recent years towards concentration of production and the desire to develop cheaper methods of

distribution in order to keep pace with the efficiency of production have led to a similar concentration of purchasing and planning in the retail field. The modern chain store is part of a system in which the merchandise planning and buying are centralized in an organization at headquarters and a central warehouse is used to accumulate and distribute merchandise to the various units as it is needed. However, single-store independent merchants still operate 80 per cent of the retail stores of the United States and do 64 per cent of the total retail business. The total retail business was distributed among the various types of organization in 1929 as follows:

	Per Cent
Single store independents	64.11
Local multi-unit independents	8.84
Local chains	6.71
Sectional and national chains	12.52
All other types of operation	7.82

The "all other" types of operation include the catalog business done by mail-order houses which, while an important channel of buying for some rural areas, amounts to only 1.05 per cent of the retail trade of the country. The sales made in the retail stores established by these concerns in a number of large cities are included in the sales of national chains. Other types of outlets are manufacturer-controlled chains such as are maintained by the makers of certain typewriters, plumbing equipment, etc., house-to-house selling, utility-operated retail stores, and leased department chains, mainly in department and apparel stores.

Certain features of chain store selling make it more adapted for use in urban than in rural territory. The costs of moving goods from wholesale centers and the uncertainty of a quick turnover are drawbacks to chain operation in remote areas, and the specialized line of goods and the emphasis placed upon cash dealings make such establishments ill-suited to many rural districts. Consequently the percentage of the total retail sales made in the several states by chains is closely related to the

percentage of the population living in urban territory. Rhode Island, with 23 per cent of its retail sales made by chain stores, shows the highest proportion (except for the District of Columbia, with 25 per cent), and Mississippi the lowest, with slightly more than 7 per cent.

The kinds of stores as well as the types of organization are determined to some extent by the type of community. Highly specialized stores such as book stores, shoe stores, women's ready-to-wear apparel stores, and certain types of food stores can exist only in areas of concentrated population or in suburban areas with high purchasing power. Sparsely populated areas can only support (and can be well served by) the more general store, ranging from the department and variety stores found in most cities of whatever size down to the country general store.

Commodities Sold by Retail Stores

The data reported by the census as to the lines of goods sold by the various types of stores are of little general interest, but may be useful in case it is desired to obtain an idea of the approximate distribution by commodities of the total sales by a particular type of store. At best, the figures are rough approximations, since it was impossible to obtain records of the commodity sales of a large share of the retail establishments. Large organizations such as department stores and stores handling a relatively small number of different lines, such as automotive dealers, were able to report in detail, but the multitude of small neighborhood stores keep no classified records.

From the figures that are given, however, it is clear that the outlets for retail goods are of the greatest variety and that the type of store which predominates in the total sales of a commodity depends upon local conditions rather than upon what appear to be its logical channels. Local prejudices, the special merchandising ability of some dealers, and the economic status of the community are apt to be the deciding factors.

Expenses of Retail Selling

The average expense of carrying on a retail business is about double that of doing a wholesale business, if expenses are measured as a percentage of total sales. The average retailer's cost in the United States was $24.83 per $100 of sales in 1929. The necessity for being well located makes the average rent fairly high, and the wages of sales people amount to a higher proportion of the sales than in wholesale trade.

Retail Sales as a Measure of Purchasing Power

The distribution of retail stores and sales throughout the United States indicates in a broad way the buying power of the population in various sections of the country. There are, however, exceptional conditions which must be considered in evaluating the figures on this subject. It should always be borne in mind, in the first place, that stores must be established in strategic locations and, in the second place, that the census figures were collected on the basis of political subdivisions and not with regard to the buying habits of a population group. Taking the case of the rural territory as an example: According to the population census 30,000,000 people, almost 25 per cent of all those in the United States, were living in 1930 on farms in the open country, where necessarily there are few stores. They are served, for some buying purposes, by stores in small towns and villages, but such stores can deal for the most part only in staple commodities in day-to-day demand. Consequently, both the farm and the village population depend upon somewhat larger communities for other types of goods. However, in spite of the fact that its residents make some of their purchases in other localities, the area outside cities of 10,000 or more inhabitants reported 44 per cent of the retail stores and 30 per cent of the retail business in 1929; clearly, with 53 per cent of the country's population, it is an area not to be neglected as a market possibility.

The extent to which the trade territories of cities of 10,000

and over reach into the surrounding area is often of interest. The overlapping of the tributary areas of large places frequently makes it difficult to obtain data for a single city; but an analysis of 14 middle-western and southern cities (ranging in size up to 400,000 inhabitants) indicates that such communities dominate the retail buying of the remainder of the counties in which they are located and that there is about an even chance that this influence will extend through the adjacent counties. In each case the part of a county outside the city of 10,000 or more showed a much smaller proportion in respect of the total retail business done in the corresponding area of the state than it did in respect of the proportion of various facilities which may be regarded as indicators of purchasing power, such as radios, residence telephones or domestic electric meters.

While the large city evidently exerts a considerable pulling power over its surrounding territory, broad areas exist in which there are no sizeable cities. In fact 2,457 counties, or 80 per cent of the total number in the United States, have no place as large as 10,000 population. In these regions the county seat is apt to be the principal trading center. It is ordinarily located near the center of the county and is reached by the best of the county roads; its position as the center of local government and the headquarters of county organizations adds to its drawing power. A study made by the Census Bureau of the retail business done in a representative sample of these communities indicates that the volume of retail business transacted in them usually far exceeds the volume warranted by their population alone.

County Seat Towns Analyzed	Number	Per Cent of Total
Total	727	100
Doing over 50 per cent of County Business	444	61
Containing over 50 per cent of population of these counties	26	
Containing from 25 to 50 per cent of population of these counties	183	
Containing less than 25 per cent of population of these counties	235	
Doing from 30 to 50 per cent of County Business	182	25
Containing over 50 per cent of population of these counties	—	
Containing from 25 to 50 per cent of population of these counties	3	
Containing less than 25 per cent of population of these counties	179	
Doing less than 30 per cent of County Business	101	14

While the county seat is frequently the largest incorporated place in the county, its attraction as a shopping center tends to be greater than that of other places of the same size. In Ohio, for example, there are 91 places of between 1,000 and 5,000 population in counties where there are no cities of 10,000 or more. Of the 91 towns, 29 are county seats, in which the average retail sales per capita in 1929 were $760, while in the remaining 62 the average was $568 per capita.

Since there exist these special conditions which influence the buying habits of localities, the question may be raised as to what value the retail sales figures have as a measure of market. A test made of the retail sales per family in the rural counties of Ohio, Alabama, Missouri and Oregon—areas representing diverse economic conditions—indicates that the relative grade of a rural market is likely to appear approximately the same measured by an index of retail sales as by one based on several items, including the number of radios, passenger automobiles and domestic electric meters per 100 families. It is also true that the average sales per establishment among the kinds of stores most common in rural areas are almost consistently high in regions which might be judged from other measures to be good markets, while a large proportion of sales made in country general stores and a high density of such stores are usually associated with poor market areas. It seems that the greatest value of the retail sales data in general will be gained from their use in conjunction with other indications of the type of the market, including data on the characteristics of the population and its economic activities as well as on the extent to which certain facilities have already been sold. It also appears that retail sales per family used alone can be considered a valid measure of the market in areas not too strongly affected by the influence of near-by cities.

Conclusion

The nature of the distributive function makes the field of distribution a large potential market for telephone service. The distance often existing between wholesalers and retailers, added to the need of keeping retail stocks constantly at a reasonably high level, should make the telephone a natural connective link. Moreover, determination of the location of the best markets is an essential part of the procedure of bringing together materials of scattered origin for processing and distributing the finished products to retailers and ultimate consumers. This is perhaps especially important in the case of perishable commodities which undergo no processing beyond sorting and packing, but which must reach the proper markets promptly.

The Census of Distribution shows that wholesale trade tends to be concentrated in the largest cities and that the great number and variety of outlets, both wholesale and retail, make possible a choice of channels by the producer or distributor of any commodity and provide the dealers themselves with a problem in competition. It also indicates that a considerable proportion of the total transactions involved do not take place according to the popular conception of the distributive process.

In the retail field the fact that the independent dealer still maintains his pre-eminent position in spite of various kinds of competition is brought out by the census figures. Equally interesting and useful are the facts shown as to the influence of large cities on the buying habits of their surrounding areas and the importance of county seats as trading centers in areas where there are no large urban places. It seems probable that local telephone usage and local toll usage stand to gain as urban retail merchants develop their facilities for handling telephone business and as their trade territories tend to expand further into rural areas.

The retail sales data will be important to many in that they

provide a new measure of potential markets. Retail sales per family appear to rank with other indexes already widely used. These data are probably somewhat less reliable than the other measures in highly urbanized territory if used alone, but in conjunction with other indexes should make possible a well-based decision as to the quality of the market offered by any particular area.

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